Written evidence submitted by HEICCAM Network

Heat Resilience and Sustainable Cooling – Call For Evidence

The authors

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The authors of this evidence are members of the HEICCAM network, which is part of the UKRI NERC Clean Air Programme. We explore the Health and Equality Impacts of Climate Change Adaptation Measures upon indoor and outdoor air pollution, specifically by examining the impact of home energy efficiency measures upon air pollution. Our membership and stakeholders include academic researchers, health practitioners, industry, and policy makers.

With our strong and diverse expertise spanning chemistry and atmospheric sciences, health, social science, architecture, and building physics, we felt particularly well placed to respond to this call for evidence by focusing on overheating risks indoors (especially in homes). While the main focus of HEICCAM network is on air quality both indoors and outdoors around the home under net zero policies, overheating and air quality are inextricably linked. Our expertise includes sustainable home design, social science and indoor air chemistry, all of which are highly relevant to this inquiry, and several of our members are directly involved in research on overheating and thermal comfort. The indoor environment is often overlooked, despite the population spending the majority of their time there. Considering recent record-breaking temperatures, we argue that a better understanding of the indoor environments we live and work in is crucial and overdue if we want to build a healthier, more just future.

Q1: What evidence exists on the relationship between heat and human health (mortality and morbidity), and which communities are worst affected?

Heat has wide-ranging impacts upon human health, and some population groups are more affected than others - whether through more intensive exposure to heat (such as homeless people or those who work outside), physical and health conditions that make them more vulnerable (such as cardiovascular illness), or often a combination of these factors. Socio-economic inequalities also lead to greater extreme heat exposure.

Impacts of heat on human health

In the short term, heat impacts the body's ability to regulate internal temperature leading to illnesses such as dehydration, heat exhaustion and hyperthermia (overheating of the body). In the longer term, chronic conditions are worsened, leading to accelerated death from diseases such as cardiovascular illnesses, diabetes and strokes[i]. Extreme heat events can work synergistically with air pollution (another major environmental risk factor) to trigger cardiovascular disease[ii].

Those at most risk from heat exposure are young children and babies, older people (especially 75+ years), those who live alone, those with underlying health conditions and those who spend most of their time outdoors, especially if undertaking hard manual labour (e.g., construction)[iii]. Those with underlying health conditions (such as cardiovascular conditions) will be strongly impacted by heat because the body has to work harder to keep cool, especially the heart, lungs and kidneys[iv].

Exposure inequalities

Exposure is important when considering which communities are most affected by overheating. For example, people who work outdoors (such as construction workers) or homeless people will be impacted from outdoor heat, whereas those at most risk from overheating in homes are people who spend most of their time indoors, such as older people and disabled people who are less likely to leave their houses.

Socio-economic inequalities also lead to different exposures to heat. For example, lower income residences in London were found to be more airtight and are less likely to have adequate (or working) ventilation[v]. Within cities especially, lower-income communities tend to live in more densely built areas, which heat up considerably more than rural areas (or those with expansive green spaces, such as parks or large gardens). Lower income communities also more frequently live in flats and other small, high-density housing[v] which are more prone to overheating than detached dwellings[vi]. Those who live in built up areas are also less likely to open windows due to noise, pollution, or security issues. A recent study of flats in London[vii] found that security concerns were the main reason for occupants in London to not open windows, even in uncomfortable levels of heat.

Furthermore, occupants that do not own their home (i.e., renters) may not be able to make changes to the home that would mitigate heat exposure (such as installing ventilation and air conditioning). Results from the Energy Follow-Up Survey (EFUS), showed that in England, local authority-owned housing was at greater risk of overheating during a heatwave[vi]. Similarly, there was a relationship between household income and prevalence of overheating; prevalence of overheating increasing with decreasing household income.

Heat and air pollution

Excessive heat can also impact health indirectly through changing exposure to air pollutants. Hot and dry conditions can increase particulate matter concentrations from emission sources such as wildfire smoke and soil dust[viii] and can accelerate the formation of ground-level ozone, exposure to which can damage the respiratory system[ix]. Ventilation of indoor spaces with outdoor air to relieve heat build-up in the home can lead to ingress of higher levels of harmful pollutants, depending upon the

surroundings. This is especially true during the night, when windows are often opened to take advantage of cooler night air. Air pollution has been shown to significantly exacerbate and contribute to a number of health conditions, including cardiovascular and respiratory disease. The groups most vulnerable to the health effects of air pollution are similar to those vulnerable to adverse health effects from overheating, mainly older and young people and those with underlying health conditions, placing a double burden on these communities and the healthcare system.

Q3: What actions can be taken to protect those most vulnerable to the impacts of extreme heat?

Adapting buildings to better protect inhabitants from extreme temperatures is crucial for protecting people in their home environments. As mentioned above, the most vulnerable often rely on this indoor environment the most. We have outlined a number of architectural approaches and policy initiatives below (Question 6), however, ventilation and cooling systems in the home require inhabitants to align their behaviours with the systems in use to ensure their effectiveness. Ventilation and cooling systems must be accessible and well-documented to encourage residents to engage, thereby ensuring the systems' effectiveness.

Behavioural aspects in the use of ventilation and cooling systems

In recent decades, the importance of ventilation and cooling systems for maintaining a comfortable and healthy indoor environment has been widely recognised. Under heatwave conditions, ventilation is most effective during the night, if outdoor air is cooler. During the day, windows should be kept closed to avoid ventilating with warmer air due to higher outdoor temperatures, and therefore cooling systems are important.

To protect vulnerable people from extreme heat, ventilation and cooling systems in houses must be effective. Key behavioural factors for the success of ventilation and cooling systems are: accessibility and adjustability of controls (in particular for occupants with varying needs and requirements); the ability to override automatic controls; use of existing occupant knowledge about building operation; easy maintenance and good documentation. The operation of cooling systems and ventilation must be clear: for example, recent work on smart homes points to challenges for residents, not only in the use of smart controls, but also in using thermostats effectively[x]. Ease of use and adaptability of cooling systems is especially important where the heat tolerance and temperature preferences of occupants differ from the presumed norm, which has been suggested to be the case for older people, for example[xi].

Accessibility and inequalities

Natural ventilation (opening windows) may not be an option for some occupants, for example due to living near a busy, polluted road, security concerns, non-openable windows or individual factors, such

as disability / low mobility that may hinder the occupants' ability to frequently access and operate windows or other ventilation or cooling systems. According to the latest English Housing Survey (EHS) Energy Follow-Up Survey (EFUS), for example, 36% of flats report no openable window, compared with 6% of houses[xii]. It is therefore important to ensure that ventilation and other cooling systems are accessible for occupants, and that alternatives are available when using natural ventilation is not possible.

Q6: What can be done to protect the UK's existing public and private sector housing stock from the impacts of extreme heat while ensuring that homes are sufficiently warm in the winter months?

From a building sciences perspective, there are two main ways of mitigating overheating in the built environment - mechanical cooling (e.g., air conditioning) and passive cooling approaches (which operate using little to no energy). House building and retrofit regulations can help to ensure that these are more widely adopted. However, in order to protect the UK's housing stock from future extreme temperatures, it is important to ensure that these regulations are followed, through educating and supporting practitioners. The move towards net-zero housing could create overheating risks as air exchange is limited, and so this must be balanced by accessible ventilation and/or cooling systems in the home.

Passive cooling approaches

There are a number of different passive cooling approaches, ranging from modifications to the building environment (especially landscaping using green spaces and water features) to modifications to the building exterior. These can be aimed at reducing heat absorption (e.g., through reflective paint) or by delaying the transfer of heat to the inside of the building (primarily through materials with high 'thermal mass', like bricks and concrete, which absorb heat during the day and do not release it to the inside of the building until several hours later, usually during the night)[xiii]. Due to its very low energy consumption, passive cooling can be a more sustainable approach to reducing overheating and can easily align with net zero targets.

A very effective passive measure to reduce indoor overheating is to install easily operational external shutters. A modelling study in the UK's West Midlands has shown that provision of external shutters can reduce heat related mortality by 37–43%[xiv]. If it is not possible to install external shutters, blinds or curtains can be kept closed during the day to reduce heating from solar radiation.

Passive heating co-benefits

As most passive cooling methods cannot simply be switched off (in the same way an air conditioning system can, for example) it is important that local climatic conditions are carefully considered to ensure they do not cause the need for more heating during the winter[xv]. The aforementioned example

of shutters can be very versatile, as they can simply be kept open to allow the sun into the building during colder days, or provide additional protection from draughts during cold and windy days. Their effectiveness, however, relies heavily on occupant behaviour.

Insulation of walls and roofs (with the aim of increasing the energy efficiency of buildings, particularly during the heating season) can also have benefits during the summer. This is especially true for top-floor flats and roof insulation[xiv]. However, individual factors such as building orientation and other passive cooling methods need to be carefully considered under the local climatic conditions[xvi].

Regulation on House Building

The overarching responsibility for preventing the overheating of the existing and future housing stock lies with the government. The UK Government recently introduced a new overheating standard - Approved Document O[xvii], thereby acknowledging the importance of extreme heat events in housing. Furthermore, in both retrofitting and new housebuilding, reducing carbon emissions is key, as the UK is committed to reaching Net Zero carbon emissions by 2050[xviii]. The Future Homes Standard will complement the Building Regulations to ensure that new homes built from 2025 will produce 75-80% less carbon emissions than homes delivered under the old regulations. It will set out energy and ventilation standards for non-residential buildings and existing homes, including proposals to mitigate overheating in residential buildings. However, there is an urgent need for much stronger systems of enforcement to ensure compliance with this requirement.

As identified by the Hackitt Review[xix], there are a number of issues in current building practice with regards to following regulation. These issues include ignorance (misunderstanding or not reading guidelines); indifference (prioritising speed rather than quality), ambiguity on who is responsible for changes, and inadequate enforcement. Another issue is that of a 'skills gap'[xx], wherein practitioners are not properly equipped and/or trained to meet regulation.

This gap between regulation and practice can be expected to result in built housing which does not reflect the original housing design. Common factors that contribute to the gap in performance include inadequate specification, improper installation and commissioning (as a result of aforementioned skills gaps in practitioners), poor coordination between design teams and contractors, and lack of occupant knowledge (in the operation of cooling systems).

Energy Efficiency and Net Zero

In reducing carbon emissions from new homes (under the 2050 Net Zero target and the Future Homes Standard), energy efficiency measures are taken to reduce air exchange in buildings, thereby making homes more energy efficient. However, these actions (specifically, sealing of the building envelope) could increase the risk of overheating, through energy not dissipating from the building[xxi]. This sealing of the building envelope can have a similar impact upon indoor air quality, by trapping internally-generated pollutants inside.

It is therefore key that solutions to reduce the impact of extreme heat while also keeping warm in the winter are performed in a low-carbon manner, to future-proof housing towards net zero. However, such measures should be balanced with good ventilation and temperature monitoring to avoid poor indoor air quality or overheating impacts. To achieve this, regulation in both new house building and current building stock retrofitting must be properly followed and enforced, while educating practitioners on good practice.

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